Research by Federal Agencies That Will Affect Future Computing Paradigms for Aerospace

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National Coordination Office (NCO) for Information Technology Research and Development (IT R&D)

Mission: To formulate and promote Federal information technology research and development to meet national goals

- NCO Director reports to the Director of the White House Office of Science Technology Policy (OSTP)
- Coordinates planning, budget, and assessment activities for the Federal multiagency Networking and Information Technology Research and Development (NITRD) Program
- Supports the six technical Coordinating Groups (CGs) that report to the Interagency Working Group (IWG) on IT R&D
  - Research planning workshops, conferences, and meetings
  - Presentations, white papers, and research reports
- Provides technical and administrative support to the IWG and President's Information Technology Advisory Committee (PITAC)
- Informs the public of Federal achievements and challenges in IT R&D
  - Maintains a Web site
  - Publishes annual budget documents in cooperation with the IT R&D agencies
  - Publishes PITAC reports

Publications

- Annual publication of the Supplement to the President's Budget also known as the "BLUE BOOK," describes the NITRD Program

  http://www.itrd.gov/pubs/blue03/03BB-final.pdf

- President's Information Technology Advisory Committee (PITAC) reports

Transforming Access to Government Through Information Technology
http://www.itrd.gov/pubs/pitac/pres-transgov-11sep00.pdf

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Developing Open Source Software to Advance High End Computing
http://www.itrd.gov/pubs/pitac/pres-oss-11sep00.pdf

Digital Libraries: Universal Access to Human Knowledge
http://www.itrd.gov/pubs/pitac/pitac-dl-9feb01.pdf

Transforming Health Care Through Information Technology
http://www.itrd.gov/pubs/pitac/pitac-hc-9feb01.pdf

Using Information Technology To Transform the Way We Learn
http://www.itrd.gov/pubs/pitac/pitac-tl-9feb01.pdf

Grid Technology Opportunities and Needs

- Large Scale Networking Workshop on Middleware and Grid Technology, August 13-14, 2002 - to be published
- Grid technologies foster collaboration and distributed access that are fundamental to the new ways of doing interdisciplinary research
- Significant new capabilities are needed to support near-term needs of discipline sciences (Network for Earthquake Engineering Simulation, Large Hadron Collider at CERN, Genetics database, …)

- Generalized capabilities and standards are needed now to prevent each discipline science from developing its own unique Grid capabilities (Balkanization)

Grid Technology Needs, Concluded

- Industry is not focused on the longer term research needed to further develop the Grid. Federal research is needed.

- New technical capabilities are needed
  - Testbeds and prototypes for simulations and collaboratories
  - Persistent, reliable, high-performance infrastructure
  - Grid economics and accounting
  - Security implementation
  - Standards applying across disciplines and international boundaries
  - Policies for interacting, sharing, and accounting
  - Multidisciplinary, robust, easy-to-use Grid technology and tools

Grid Communities & Applications: High Energy Physics Problem Scale

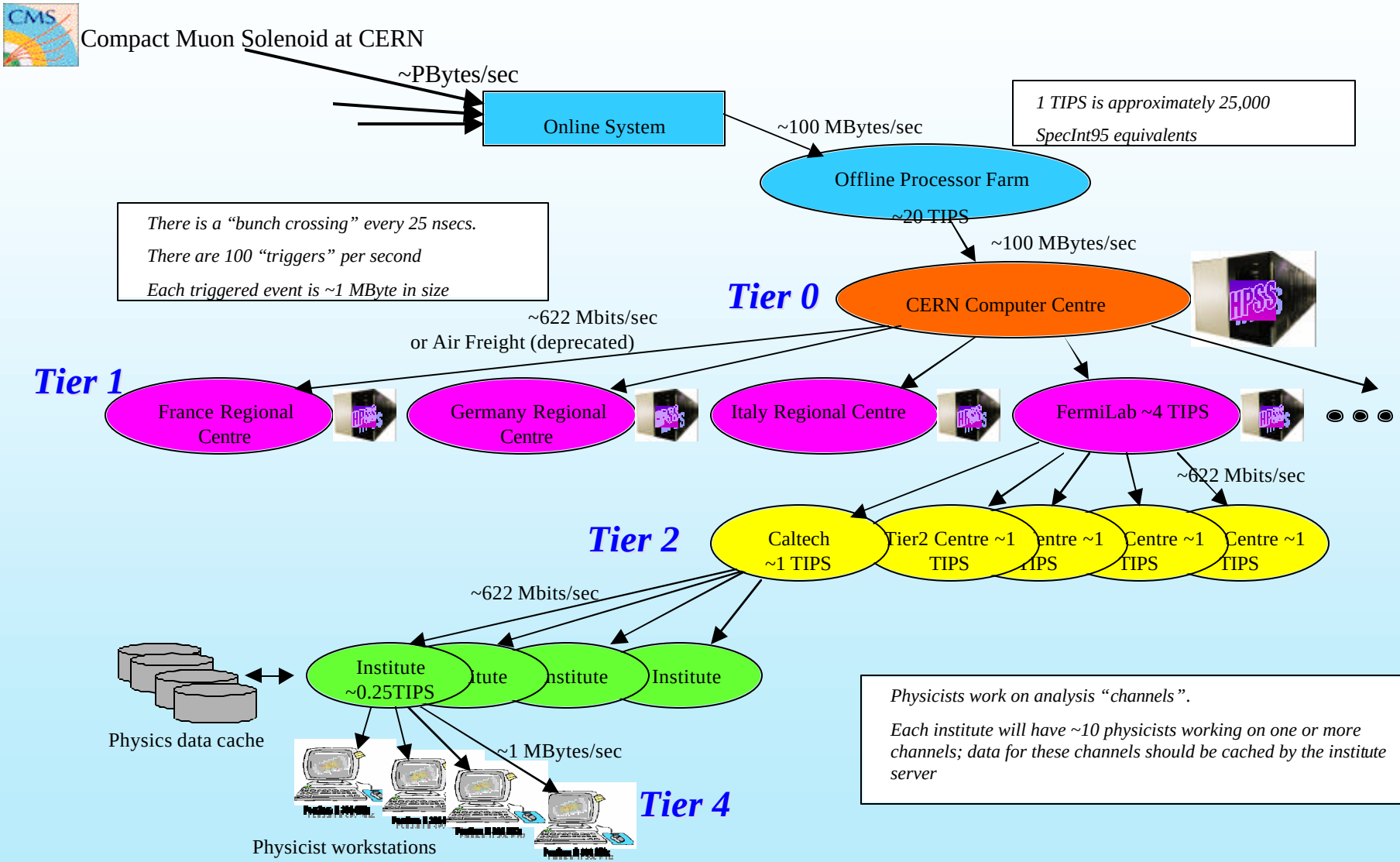


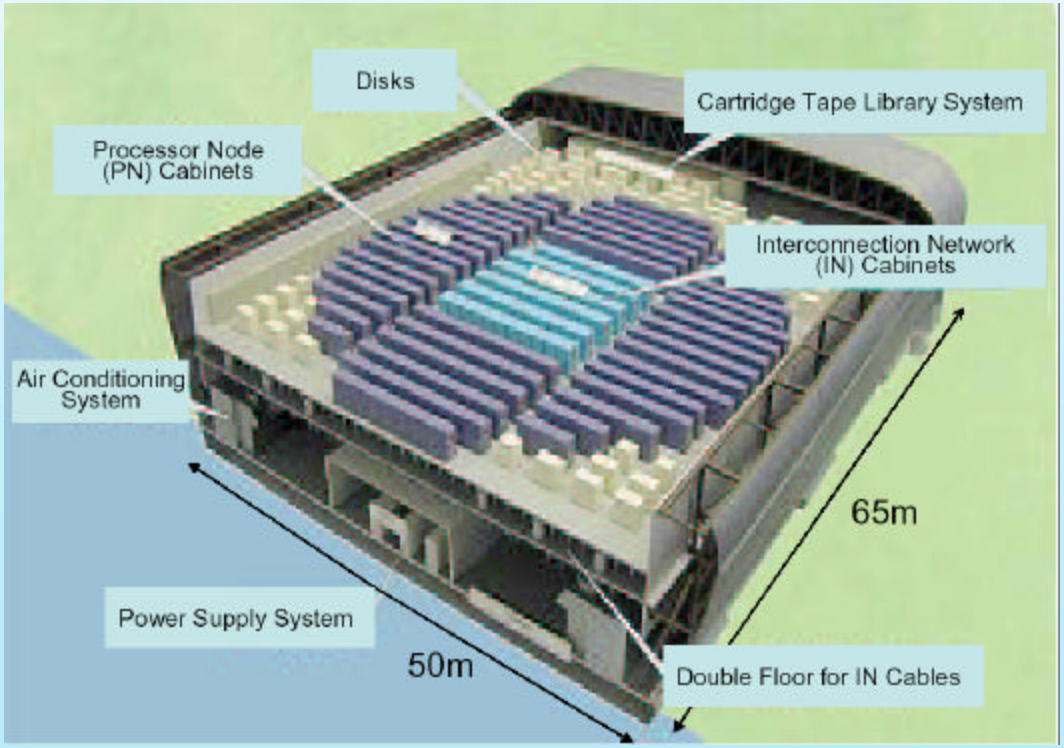
Image courtesy Harvey Newman, Caltech

Grid Technology Scenario from Workshop

- Virtual National Airspace Simulation Environment
- Grid Technology Requirements
  - Access to distributed computational resources to support real-time simulations
  - Access to distributed simulation models
  - Access to distributed information resources
  - Real-time access to on-line sensor data, e.g. weather sensors, on-board aircraft sensors
  - Priority for commanding use of resources
  - Security,
  - Reliability, robustness for critical functions
  - Collaboration technology and user interfaces
  - Real-time monitoring and management of Grid tools and resources

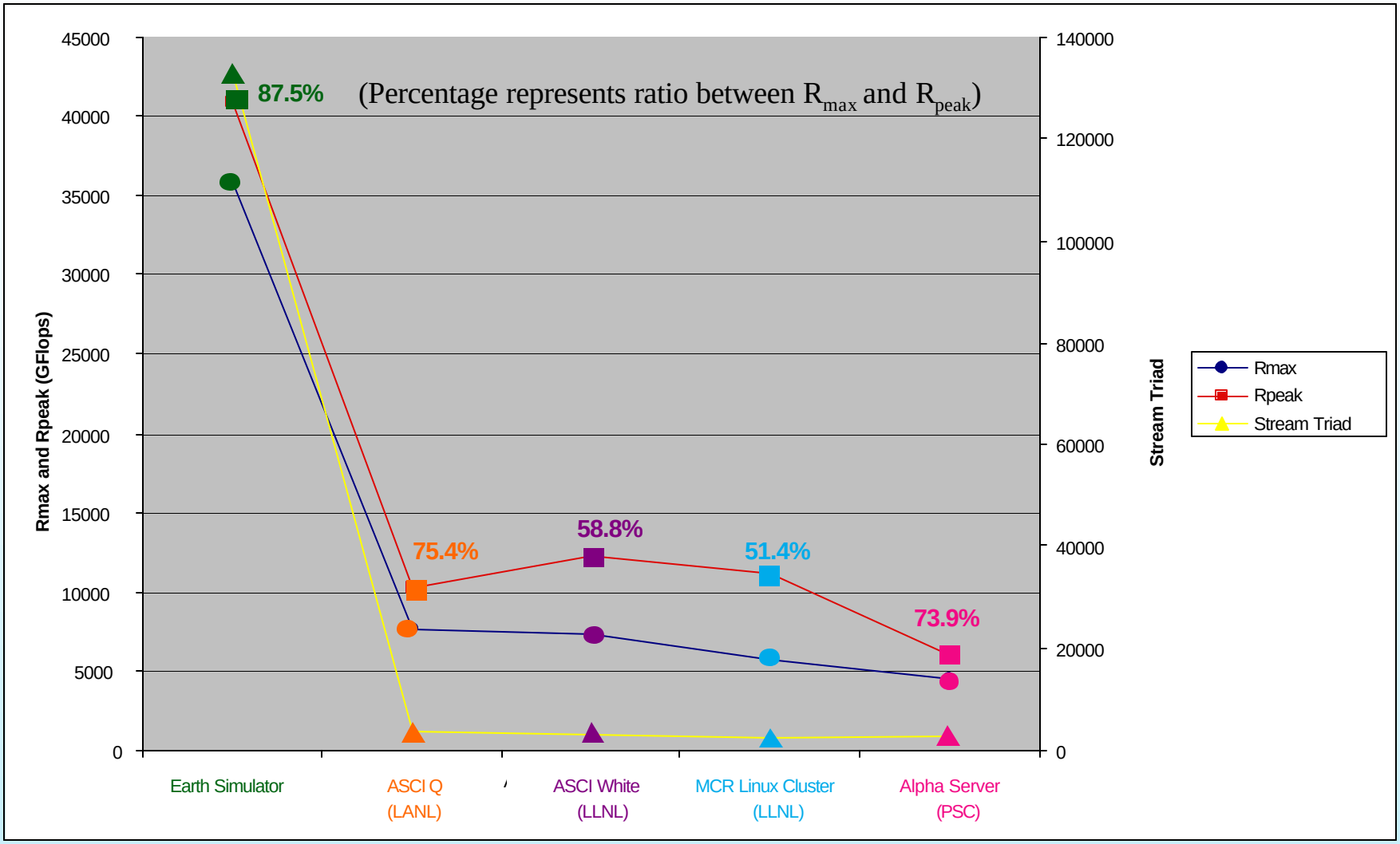
Earth Simulator Has Inspired a New Look at U.S. High End Computing

- Based on the NEC SX architecture, 640 nodes, each node with 8 vector processors (8 GFlop/s peak per processor), 2 ns cycle time, 16GB shared memory
  - Total of 5104 total processors, 40 TFlop/s peak, and 10 TB memory
- Has a single stage crossbar switch(1800 miles of cable) 83,000 copper cables, 16GB/s cross section bandwidth
- 700 TB disk space
- 1.6 PB mass store
- Area of computer = 4 tennis courts, 3 floors



Source: http://www.es.jamstec.go.jp/esc/eng/outline/outline02.html

Performance Measures of Selected Top Computers



Several Federal Agencies Have Recently Examined High End Computing Needs

- They are mostly using COTS-based HEC
- Most expect COTS to be acceptable in near term, however:
  - Time-to-solution becoming too long
    - Too hard to program; too hard to optimize
  - Coordinated improvements are needed in hardware, software, and application algorithms
  - Rapidly escalating demand on HEC facilities
- Some important applications/algorithms are not amenable to COTS-based HEC
  - Primarily due to non-local memory reference e.g., long vectors requiring gather-scatter operations

Examples of Applications for Which COTS May be Unsuitable

- Hypersonic air-breathing propulsion
  - Needs high memory-to-CPU bandwidth for multi-disciplinary analysis
- Reusable Launch Vehicle Design
  - Needs high memory-to-CPU bandwidth
- Protein Folding
  - Poorly parallelizable
- Cryptoanalysis
  - Needs fast flat-memory model
- Climate data assimilation
  - Part of problem not easily parallelizable, needs high memory-to-CPU bandwidth

Agency Conclusions

- Further progress in HEC will require balanced, coordinated effort in
  - Research, development, and engineering of new HEC architectures and systems
  - Procurement of new COTS and custom systems
  - Better software (systems, middleware, and applications)
  - Better domain science (mathematics and algorithms)
- HEC is a decreasing part of the technical computing marketplace.
- COTS-based HEC is largely based on technologies developed for low- and mid-range markets (SMP nodes, low bandwidth interconnects).
- Market pressure may result in future COTS systems being less responsive to HEC needs.
- Federal funding of highest-performing HEC, including development of new systems, may be required.

High End Computing Revitalization Task Force (HECRTF) Charge

- Rationale: High End Computing (HEC) increasingly critical
- HECRTF coordinated through National Science and Technology Council (NSTC)
- To develop a plan that can guide future Federal HEC investments
- Plan will lay out an overall strategy for these investments
- Seek wide participation by Federal agencies developing or using HEC
- Final report to be completed by August 2003, in time to be an input to FY 2005 budget

For Further Information

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